6. Summary and Conclusions

The results presented in section 5 are based on one WRS scene assuming that the average instructions take two cycles to execute. This section presents the analysis results with different numbers of CPU cycles for average instructions, different scene sizes, and different workloads.

6.1 Number of CPU Cycles for Average Instructions

The assumption of the CPU speed for average instructions plays a significant role in the total service time estimate. As discussed in Section 4.5.3, this analysis assumes two cycles per instruction. Detailed analysis of the total service time and CPU utilization as a function of the number of CPU cycles for average radiometric processing instructions will be discussed in Section 6.3.

6.2 Scene Size

The estimates of instruction counts and amount of data transferred presented in Section 5 (except memory requirements) are calculated based on the worst case average scene size of one full scene. The worst case average scene size is useful when dealing with throughput and disk storage requirements which use a representative file size, data volume, and/or service time for “average” scenes. The LPGS has a requirement to generate Level 1 images corresponding to a partial ETM+ subinterval up to three WRS scenes. The resources required vary depending on the actual scene size. Processing two one-half scenes will require more overhead than processing one full scene. However, the file size of a three-scene L1G image is also much larger than the combined file size of three full-scene L1G images. The file sizes, data volumes, and memory requirements for different scene sizes are discussed in this section. While the service time and resource utilization, which vary depending on the scene size and workload will be presented in Section 6.3.

6.2.1 Data Volume and File Size (actual scene size)

Comparisons of the data volumes and file sizes for different scene sizes are shown in Tables 6–1. Ratios of the data volumes and file sizes for different scene sizes with respect to one full scene (scaled to the same number of scenes) are shown in Table 6-2.

Table 6–1. Comparisons of Data Volumes and File Sizes for Different Scene Sizes (actual scene size)

	1 1/2-WRS Scene (Megabytes)	1 1-WRS Scene (Megabytes)	1 2-WRS Scene (Megabytes)	1 3-WRS Scene (Megabytes)
Disk I/O for nominal processing	11221.76	21341.78	43397.05	67876.66
FDDI data transfer for nominal processing	817.87	1611.31	3198.06	5041.75
Disk I/O for non-nominal processing	3427.48	6697.27	13539.08	20785.24
FDDI data transfer for non-nominal processing	3427.48	6697.27	13539.08	20785.24
L0R product	249.10	487.13	963.16	1439.24
L1R Band 1/2/3/4/5/7 image	39.50	79.00	157.98	236.98
L1R Band 6 image	9.88	19.76	39.50	59.26
L1R Band 8 image	157.98	315.96	631.92	947.88
L1R product	494.42	977.70	1944.17	2910.74
L1G Band 1/2/3/4/5/7 image	46.00	79.18	172.39	301.40
L1G Band 6 image	11.50	19.79	43.10	75.35
L1G Band 8 Image	184.01	316.71	689.54	1205.60
L1G product	489.81	837.14	1807.10	3144.09

Table 6–2. Ratios of Data Volumes and File Sizes for Different Scene Sizes with Respect to a Full Scene (actual scene size)

	2 1/2-WRS Scenes (Megabytes)	1 1-WRS Scene (Megabytes)	1/2 2-WRS Scenes (Megabytes)	1/3 3-WRS Scenes (Megabytes)
Disk I/O for nominal processing	105.16%	100.00%	101.67%	106.02%
FDDI data transfer for nominal processing	101.52%	100.00%	99.24%	104.30%
Disk I/O for non-nominal processing	102.35%	100.00%	101.08%	103.45%
FDDI data transfer for non-nominal processing	102.35%	100.00%	101.08%	103.45%
L0R product	102.27%	100.00%	98.86%	98.48%
L1R Band 1/2/3/4/5/7 image	100.00%	100.00%	99.99%	99.99%
L1R Band 6 image	100.00%	100.00%	99.95%	99.97%
L1R Band 8 image	100.00%	100.00%	100.00%	100.00%
L1R product	101.14%	100.00%	99.43%	99.24%
L1G Band 1/2/3/4/5/7 image	116.19%	100.00%	108.86%	126.88%
L1G Band 6 image	116.22%	100.00%	108.89%	126.92%
L1G Band 8 Image	116.20%	100.00%	108.86%	126.88%
L1G product	117.02%	100.00%	107.93%	125.19%

6.2.2 Instruction Count (actual scene size)

Comparisons of instruction counts for the radiometric processing are shown in Table 6–3. Ratios of the instruction counts for different scene sizes (scaled to the same number of scenes) with respect to one full scene are shown in Table 6-4. Processing two one-half scenes will require 11.59 percent more instructions than processing one full scene. This increase is mainly due to the memory effect correction. Excluding the memory effect correction only an additional 0.13 percent instructions are required. The memory effect correction algorithm uses a logic of 3,000 loops (6000 for Band 8) to construct a vector of 3,000 coefficients (6,000 for Band 8) for each detector, which is independent of the scene size.

Table 6–3. Instruction Counts for Different Scene Sizes for Radiometric Processing (actual scene size)

Instruction Counts for Radiometric Processing				
	1 1/2-WRS Scene (Mega Ops)	1 1-WRS Scene (Mega Ops)	1 2-WRS Scene (Mega Ops)	1 3-WRS Scene (Mega Ops)
2.1 Characterize Impulse Noise	647.542	1295.005	2589.930	3884.854
2.3 Locate Scan-Correlated Shift (SCS)	2288.772	4577.465	9154.849	13732.234
2.5 Characterize Dropped Lines	428.908	857.737	1715.394	2573.050
2.6a Characterize Detector Saturation (A/D)	1463.680	2927.279	5854.479	8781.678
2.6b Characterize Detector Saturation (Analog)	1463.679	2927.277	5854.475	8781.672
2.10a Histogram Analysis (Integer Operations)	1623.036	3242.307	6480.847	9719.388
2.10b Histogram Analysis (Floating Point Operations)	3322.339	6560.877	13037.954	19515.031
3.4.1 Process IC Data - Emissive Band	1479.466	2958.773	5917.386	8875.999
3.4.2 Process IC Data - Reflective Band	1297.953	2595.719	5191.249	7786.780
4.1.1 Combine Image and IC Data	951.975	1903.909	3807.779	5711.648
4.1.2 Correct Memory Effect (new from Dennis Helder)	67319.422	113639.153	206278.617	298918.081
4.1.3 Apply Scan-Correlated Shift (SCS)	857.380	1714.681	3429.281	5143.882
4.1.4 Apply Coherent Noise Correction	1190.038	2379.955	4759.791	7139.626
4.1.6 Separate Image and IC Data	951.974	1903.908	3807.777	5711.645
4.2 Apply Radiometric Correction	1416.941	2833.801	5667.522	8501.244
4.3.1 Correct Dropped Lines	331.064	662.049	1324.017	1985.986
4.3.2 Correct Inoperable Detectors	0.437	0.437	0.437	0.437
4.3.4 Correct Stripping	405.034	809.851	1619.487	2429.122
4.3.5 Correct Banding	14087.722	28175.364	56350.649	84525.933
6.5 Gain Switch and Apply Relative Gain Correction	0.107	0.107	0.107	0.107
TOTAL	101527.470	181965.656	342842.027	503718.398
Total (excluding memory effect correction)	34208.049	68326.502	136563.410	204800.317

Table 6–4. Ratios of Instruction Counts with Respect to One Full Scene for Different Scene Sizes (actual scene size)

Instruction Counts for Radiometric Processing				
	2 1/2-WRS Scenes (Mega Ops)	1 1-WRS Scene (Mega Ops)	1/2 2-WRS Scenes (Mega Ops)	1/3 3-WRS Scenes (Mega Ops)
2.1 Characterize Impulse Noise	100.01%	100.00%	100.00%	100.00%
2.3 Locate Scan-Correlated Shift (SCS)	100.00%	100.00%	100.00%	100.00%
2.5 Characterize Dropped Lines	100.01%	100.00%	100.00%	99.99%
2.6a Characterize Detector Saturation (A/D)	100.00%	100.00%	100.00%	100.00%
2.6b Characterize Detector Saturation (Analog)	100.00%	100.00%	100.00%	100.00%
2.10a Histogram Analysis (Integer Operations)	100.12%	100.00%	99.94%	99.92%
2.10b Histogram Analysis (Floating Point Operations)	101.28%	100.00%	99.36%	99.15%
3.4.1 Process IC Data - Emissive Band	100.01%	100.00%	100.00%	100.00%
3.4.2 Process IC Data - Reflective Band	100.01%	100.00%	100.00%	100.00%
4.1.1 Combine Image and IC Data	100.00%	100.00%	100.00%	100.00%
4.1.2 Correct Memory Effect (new from Dennis Helder)	118.48%	100.00%	90.76%	87.68%
4.1.3 Apply Scan-Correlated Shift (SCS)	100.00%	100.00%	100.00%	100.00%
4.1.4 Apply Coherent Noise Correction	100.01%	100.00%	100.00%	100.00%
4.1.6 Separate Image and IC Data	100.00%	100.00%	100.00%	100.00%
4.2 Apply Radiometric Correction	100.00%	100.00%	100.00%	100.00%
4.3.1 Correct Dropped Lines	100.01%	100.00%	99.99%	99.99%
4.3.2 Correct Inoperable Detectors	200.00%	100.00%	50.00%	33.33%
4.3.4 Correct Stripping	100.03%	100.00%	99.99%	99.98%
4.3.5 Correct Banding	100.00%	100.00%	100.00%	100.00%
6.5 Gain Switch and Apply Relative Gain Correction	200.00%	100.00%	50.00%	33.33%
TOTAL	111.59%	100.00%	94.21%	92.27%
Total (excluding memory effect correction)	100.13%	100.00%	99.93%	99.91%

6.2.3 Memory Requirements (actual scene size)

Comparisons of memory requirements for different scene sizes are summarized in Table 6-5. The memory requirements are estimated for the entire scene depending on the scene size. The main driver of the memory requirement is the processing of the Band 8 data. The amount of the memory required for the radiometric processing is pretty much the same regardless of the scene size because the processing is performed one scene at a time. The geometric processing requires to construct the entire resampled image in the memory. Therefore the amount of the memory required increases as the scene size increases. The memory requirements shown in Table 6-5 include 40 MB of the overhead and a 25-percent reserve. In addition, a total of 512 MB of memory is required for the operating system.

Table 6–5. Comparisons of Memory Requirements for Different Scene Sizes (actual scene size)

	1 1/2-WRS Scene (Megabytes)	1 1-WRS Scene (Megabytes)	1 2-WRS Scene (Megabytes)	1 3-WRS Scene (Megabytes)
L1R				
Band 1/2/3/4/5/7	231.64	356.01	357.93	359.84
Band 6	106.51	138.33	140.24	142.15
Band 8	733.58	1229.76	1234.80	1239.84
L1G				
Band 1/2/3/4/5/7	160.28	202.68	321.10	484.29
Band 6	89.90	101.20	132.24	174.48
Band 8	438.35	606.73	1078.54	1727.91

6.2.4 Service Time

Detailed analysis of the total service times for different scene sizes, which are workload related will be discussed in Section 6.3.

6.3 Different Workloads

This section discusses the resource requirements and the total service times for different workloads.

6.3.1 Workload Related Assumptions and Resource Requirements

The proposed resource requirements for the L1 Processing HWCI for the different workloads are shown in Table 6-6. Table 6-7 summaries the workload related assumptions used in the resource requirement, service time, and resource utilization estimations. The resource requirements are derived from the analysis results from Section 5 using the assumptions listed in Table 6-7. The analysis indicates an almost linear association between the number of CPUs, memory, RAIDs needed to support the workload from 25 to 100 scenes per day.

To handle increased workload, multiple CPUs will be required. The CPU performance will degrade slightly with increasing number of CPUs.

Table 6–6. Resource Requirements for Different Workloads

Workload	Workload 1	Workload 2	Workload 3	Workload 4
Required daily workload	25 + 3[(1)] scenes	50 + 5[(1)] scenes	75 + 8[(1)] scenes	100 + 10[(1)] scenes
Number of simultaneously processed product requests	4	8	12	16
Number of CPUs	4	8	12	16
Memory	6 GB (1.5 GB x 4)	12 GB (1.5 GB x 8)	18 GB (1.5 GB x 12)	24 GB (1.5 GB x 16)
Number of 72 GB RAIDs[(2)]	4	8	12	16
(1) : 10% reprocessing (2) : Assuming 64 GB of usable space for a 72 GB RAID (3) : Assuming 75% overall system utilization				

Table 6–7. Workload Related Assumptions

Workload	Workload 1	Workload 2	Workload 3	Workload 4
Required daily workload	25 + 3[(1)] scenes	50 + 5[(1)] scenes	75 + 8[(1)] scenes	100 + 10[(1)] scenes
Number of CPUs	4	8	12	16
Number of simultaneously processed product processed	4	8	12	16
CPU performance degradation factor	7%	10%	12%	14%
Number of RAID partitions	1	2	3	4
Size of input buffer	12 scenes	24 scenes	36 scenes	48 scenes
Size of in-process queue	12 scenes	24 scenes	36 scenes	48 scenes
Size of output buffer	12 scenes	24 scenes	36 scenes	48 scenes
Anomaly analysis	3 scenes per day	3 scenes per day	6 scenes per day	6 scenes per day
Number of days of trending data	30 days	30 days	30 days	30 days
(1) : 10% reprocessing				

The disk data transfer rate for a single RAID is about 35 MBPS. With multiple RAIDs in a stripped configuration, the aggregate disk data transfer rate can be multiplied. If the RAIDs are grouped together as one huge file, the maximum disk data transfer rate that it can provide is about 90 MBPS. As the workload increases, the I/O contention for the disk access also increases. The 90 MBPS disk data transfer rate will severely limit the throughput. However, if the RAIDs are partitioned into multiple groups with multiple RAIDs in each group, each group can achieve the maximum data transfer rate of 90 MBPS. This will increase the bandwidth for the disk I/O and increase the throughput. But it will require that the files for different product requests are distributed among different RAID groups and files for the same product requests are on the same RAID group. For this analysis, it is assumed that four RAIDs will be grouped together and provide an aggregate data transfer rate of 70 MBPS.

6.3.2 Disk Storage

Table 6-8 shows the amount of disk space required for different workloads. There will be enough disk space to meet the workload requirements.

Table 6–8. Disk Storage for Different Workloads

Workload	Workload 1	Workload 2	Workload 3	Workload 4
Required daily workload	25 + 3(1) scenes	50 + 5(1) scenes	75 + 8(1) scenes	100 + 10(1) scenes
Number of 72 GB RAIDs	4	8	12	16
Total disk space (GB)	288	576	864	1152
Usable disk space (GB) (2)	256	512	768	1024
Required disk space (GB) (including 25% reserve)	254.13	455.39	709.49	910.76
Utilization	99.27%	88.94%	92.39%	88.94%
(1) : 10% reprocessing (2) : Assuming 64 GB of usable space for a 72 GB RAID				

6.3.3 Workload 1 - 25 Scenes per Day

To process 25 scenes per day, the following assumptions are used (refer to Table 6-7):

- nominal processing of 25 scenes per day
- reprocessing of three scenes per day
- anomaly analysis of three scenes per day
- four CPUs
- processing four requests simultaneously
- seven-percent performance degradation for CPUs
- four RAIDs grouped in one group.

6.3.3.1 Service Time

The service time for nominal processing of different scene sizes with a seven-percent CPU performance degradation factor is shown in Table 6-9. The service time is estimated assuming two CPU cycles to execute an average instruction for the radiometric processing. Actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-9.

Table 6-10 shows the service time with various assumptions on the number of CPU cycles for average radiometric processing instructions for different scene sizes. Similar to Table 6-9, actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-10.

6.3.3.2 System Throughput

To fully utilize the available resources, in particular CPUs, four product requests will be processed simultaneously. For the worst case average scene, the total service time for one scene is 96.61 minutes assuming that the average radiometric processing instructions will take two CPU cycles to execute. However, due to the possible I/O contention among the four product requests, it will take more than 96.61 minutes to process four scenes with four CPUs. The time it takes to nominally process four scenes using four CPUs as a function of the number of cycles for average instructions is shown in Table 6-11. This processing time is estimated based on the probability of the disk being busy serving other product requests. It is assumed that the contention on the FDDI does not have effects on the processing time because the FDDI data transfer occurs prior to and after processing. Assuming that the system is 75% utilized, the amount of time it takes to process the required daily workload and the maximum number of scenes that can be processed each day are also shown in Table 6-11. Note that Table 6-11 only covers the nominal processing (including reprocessing). It does not cover the anomaly analysis.

Table 6–9. Service Time for Different Scene Sizes (workload = 25 + 3 scenes/day)

4-CPU Configuration (CPU Performance Degradation Factor = 7%) (Time in minutes)							
Scene Size	Activity	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
1/2 WRS Scene (actual)	**CPU Time**						
	Application	negligible	27.99	16.13	negligible	negligible	44.12
	Overhead associated with FDDI data transfer	0.13	0.00	0.00	0.00	0.26	0.39
	Overhead associated with RAID data transfer	0.15	1.01	0.50	0.30	0.10	2.06
	Subtotal	0.28	29.01	16.62	0.30	0.36	46.57
	Data Transfer Time						
	FDDI	0.61	0.00	0.00	0.00	1.21	1.82
	RAID	0.20	1.31	0.65	0.39	0.13	2.67
	Subtotal	0.80	1.31	0.65	0.39	1.34	4.49
	Total	1.09	30.32	17.27	0.69	1.70	51.06
1 WRS Scene (actual)	**CPU Time**						
	Application	negligible	50.17	32.25	negligible	negligible	82.42
	Overhead associated with FDDI data transfer	0.26	0.00	0.00	0.00	0.51	0.77
	Overhead associated with RAID data transfer	0.30	2.02	0.93	0.51	0.17	3.92
	Subtotal	0.55	52.19	33.18	0.51	0.68	87.11
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.39	3.58
	RAID	0.38	2.62	1.20	0.66	0.22	5.08
	Subtotal	1.57	2.62	1.20	0.66	2.61	8.66
	Total	2.13	54.80	34.38	1.17	3.29	95.78
2 WRS Scenes (actual)	**CPU Time**						
	Application	negligible	94.52	64.50	negligible	negligible	159.02
	Overhead associated with FDDI data transfer	0.51	0.00	0.00	0.00	1.02	1.53
	Overhead associated with RAID data transfer	0.58	4.03	1.90	1.10	0.37	7.98
	Subtotal	1.09	98.55	66.40	1.10	1.39	168.53
	Data Transfer Time						
	FDDI	2.35	0.00	0.00	0.00	4.75	7.11
	RAID	0.76	5.22	2.46	1.43	0.47	10.33
	Subtotal	3.11	5.22	2.46	1.43	5.23	17.44
	Total	4.20	103.77	68.85	2.53	6.61	185.97
3 WRS Scenes (actual)	**CPU Time**						
	Application	negligible	138.88	96.75	negligible	negligible	235.63
	Overhead associated with FDDI data transfer	0.76	0.00	0.00	0.00	1.65	2.41
	Overhead associated with RAID data transfer	0.87	6.04	3.01	1.92	0.64	12.48
	Subtotal	1.63	144.92	99.76	1.92	2.29	250.52
	Data Transfer Time						
	FDDI	3.52	0.00	0.00	0.00	7.69	11.20
	RAID	1.13	7.82	3.90	2.48	0.82	16.16
	Subtotal	4.65	7.82	3.90	2.48	8.51	27.36
	Total	6.28	152.74	103.67	4.40	10.80	277.88
1 WRS Scene (average)	**CPU Time**						
	Application	negligible	50.17	32.25	negligible	negligible	82.42
	Overhead associated with FDDI data transfer	0.26	0.00	0.00	0.00	0.56	0.81
	Overhead associated with RAID data transfer	0.30	2.02	1.02	0.64	0.21	4.19
	Subtotal	0.55	52.19	33.27	0.64	0.77	87.42
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.58	3.77
	RAID	0.38	2.62	1.32	0.83	0.28	5.42
	Subtotal	1.57	2.62	1.32	0.83	2.86	9.19
	Total	2.13	54.80	34.58	1.48	3.62	96.61

Table 6–10. Service Time for Different Scene Sizes as a Function of CPU Cycles per Instruction (workload = 25 + 3 scenes/day)

4-CPU Configuration (CPU Performance Degradation Factor = 7%) (Time in minutes)						
Scene	**# of Cycles/Instruction**	1	2	3	4	5
Size	**Equivalent MFLOP**	195	97.5	65	48.75	39
1/2 WRS Scene (actual)	**CPU Time**					
	Application	30.12	44.12	58.11	72.11	86.11
	Overhead associated with FDDI data transfer	0.39	0.39	0.39	0.39	0.39
	Overhead associated with RAID data transfer	2.06	2.06	2.06	2.06	2.06
	Subtotal	32.58	46.57	60.57	74.56	88.56
	Data Transfer Time					
	FDDI	1.82	1.82	1.82	1.82	1.82
	RAID	2.67	2.67	2.67	2.67	2.67
	Subtotal	4.49	4.49	4.49	4.49	4.49
	Total	37.06	51.06	65.06	79.05	93.05
1 WRS Scene (actual)	**CPU Time**					
	Application	57.33	82.42	107.50	132.59	157.67
	Overhead associated with FDDI data transfer	0.77	0.77	0.77	0.77	0.77
	Overhead associated with RAID data transfer	3.92	3.92	3.92	3.92	3.92
	Subtotal	62.03	87.11	112.20	137.28	162.37
	Data Transfer Time					
	FDDI	3.58	3.58	3.58	3.58	3.58
	RAID	5.08	5.08	5.08	5.08	5.08
	Subtotal	8.66	8.66	8.66	8.66	8.66
	Total	70.69	95.78	120.86	145.95	171.03
2 WRS Scenes (actual)	**CPU Time**					
	Application	111.76	159.02	206.29	253.55	300.81
	Overhead associated with FDDI data transfer	1.53	1.53	1.53	1.53	1.53
	Overhead associated with RAID data transfer	7.98	7.98	7.98	7.98	7.98
	Subtotal	121.27	168.53	215.79	263.06	310.32
	Data Transfer Time					
	FDDI	7.11	7.11	7.11	7.11	7.11
	RAID	10.33	10.33	10.33	10.33	10.33
	Subtotal	17.44	17.44	17.44	17.44	17.44
	Total	138.71	185.97	233.23	280.50	327.76
3 WRS Scenes (actual)	**CPU Time**					
	Application	166.19	235.63	305.07	374.51	443.95
	Overhead associated with FDDI data transfer	2.41	2.41	2.41	2.41	2.41
	Overhead associated with RAID data transfer	12.48	12.48	12.48	12.48	12.48
	Subtotal	181.08	250.52	319.96	389.40	458.84
	Data Transfer Time					
	FDDI	11.20	11.20	11.20	11.20	11.20
	RAID	16.16	16.16	16.16	16.16	16.16
	Subtotal	27.36	27.36	27.36	27.36	27.36
	Total	208.44	277.88	347.32	416.76	486.20
1 WRS Scene (average)	**CPU Time**					
	Application	57.33	82.42	107.50	132.59	157.67
	Overhead associated with FDDI data transfer	0.81	0.81	0.81	0.81	0.81
	Overhead associated with RAID data transfer	4.19	4.19	4.19	4.19	4.19
	Subtotal	62.33	87.42	112.50	137.59	162.67
	Data Transfer Time					
	FDDI	3.77	3.77	3.77	3.77	3.77
	RAID	5.42	5.42	5.42	5.42	5.42
	Subtotal	9.19	9.19	9.19	9.19	9.19
	Total	71.53	96.61	121.70	146.78	171.87

Table 6–11. System Throughput Using Four CPUs (workload = 25 + 3 scenes/day)

4-CPU Configuration (CPU Performance Degradation Factor = 7%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Time to process 4 WRS scenes Using 4 CPUs (minutes)	77.76	101.44	125.63	150.10	174.74
Maximum daily throughput (scenes/day)	51	42	34	28	24 **
Time to process 25 scenes + reprocess 3 scenes (hours)	9.1	11.9	14.7	17.6	20.4
** : can not support the required workload with the assumption that the system can only be 75% utilized					

6.3.3.3 Resource Utilization

6.3.3.3.1 CPU, FDDI, and Disk I/O

Table 6-12 shows the CPU, FDDI and disk I/O utilization as a function of the number of cycles for average instructions over a period of 24 hours. The worst case average scene size is used in the utilization calculation. Separate values are provided for nominal processing with and without non-nominal processing (anomaly analysis).

Figure 6-1 shows the CPU utilization over a 24-hour period for nominal processing of 25 scenes and reprocessing of three scenes using four CPUs as a function of CPU cycles per average instruction and actual scene size. Figure 6-2 shows the similar CPU utilization with anomaly analysis of three scenes added. Figure 6-2 shows that the CPUs can be kept less than 75 percent utilized; even the radiometric processing software only achieves 65 MFLOPS (three cycles per instruction).

6.3.3.3.2 Disk Storage

The disk storage utilization is shown in Table 6-8.

6.3.3.3.3 Memory Requirements

The memory required to process each band of data for different scene sizes is shown in Table 6-5.

Table 6–12. Resource Utilization over a 24-Hour Period (workload = 25 + 3 scenes/day)

4-CPU Configuration (CPU Performance Degradation Factor = 7%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Nominal processing & non-nominal processing					
CPU	37.27%	52.08%	66.89%	81.69%	96.50%
FDDI data transfer	15.33%	15.33%	15.33%	15.33%	15.33%
Disk I/O	13.50%	13.50%	13.50%	13.50%	13.50%
Nominal processing only					
CPU	30.30%	42.50%	54.69%	66.88%	79.08%
FDDI data transfer	7.33%	7.33%	7.33%	7.33%	7.33%
Disk I/O	10.55%	10.55%	10.55%	10.55%	10.55%

Figure 6–1. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Nominal Processing Only) (workload = 25 + 3 scenes per day)

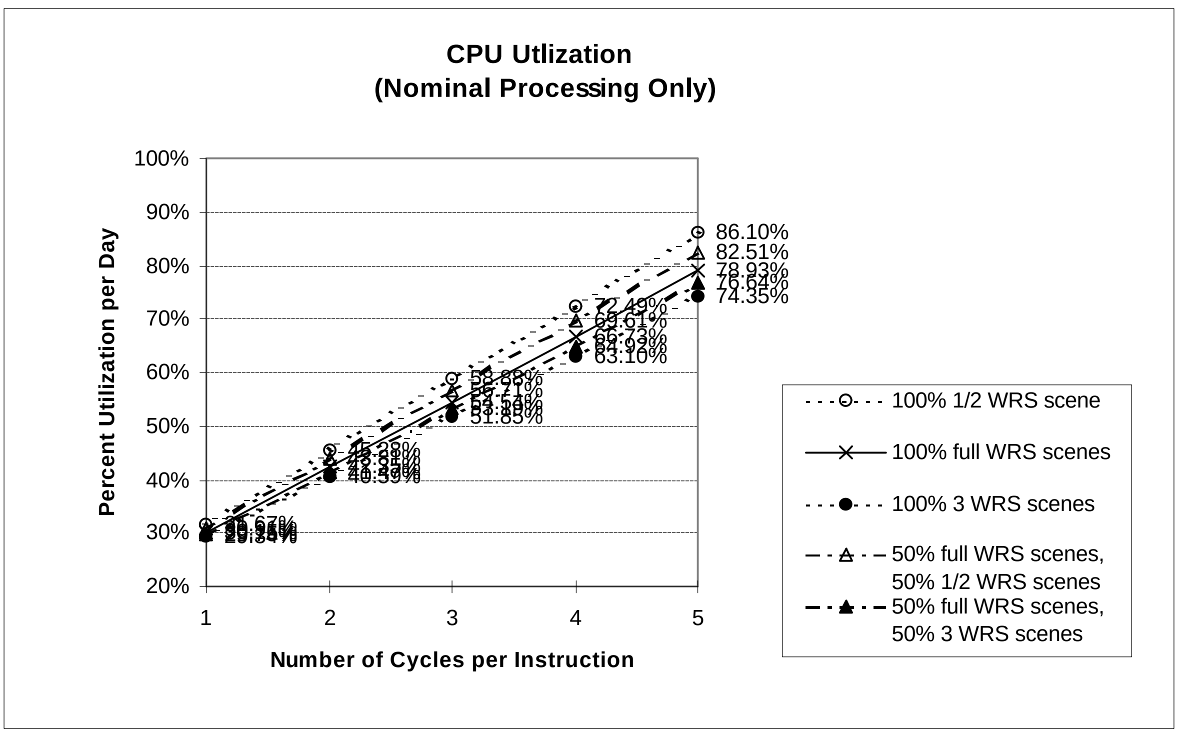
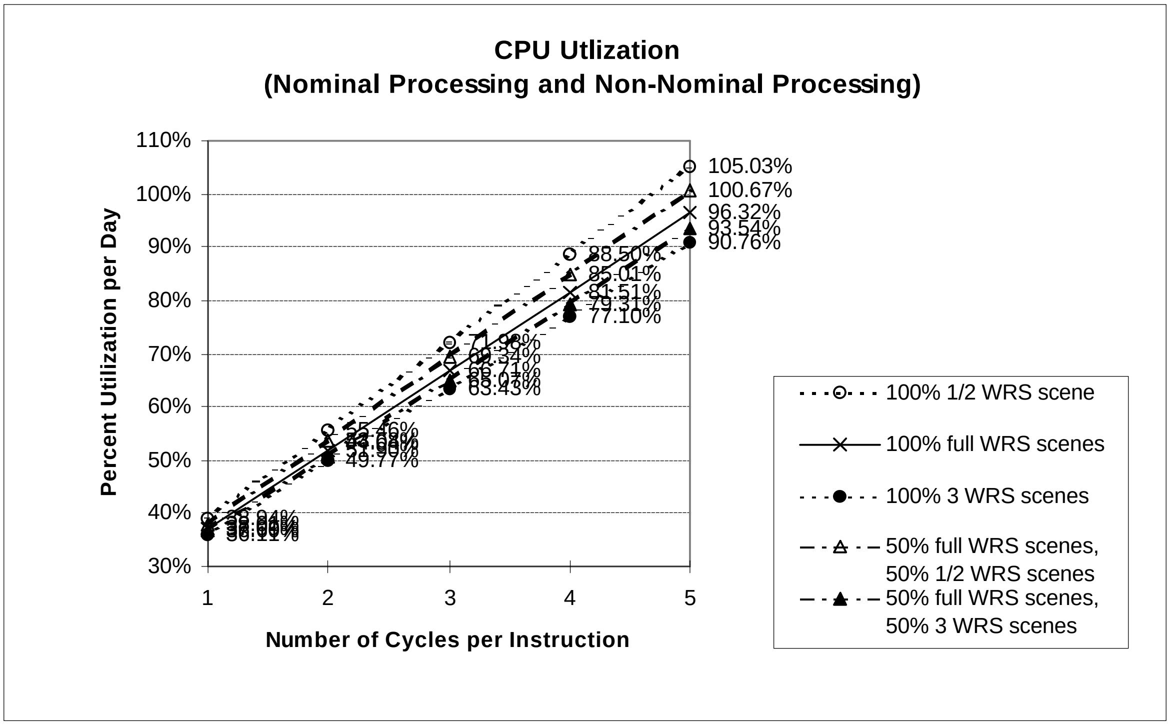


Figure 6–2. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Including Non-nominal Processing) (workload = 25+ 3 scenes per day)



6.3.3.4 Timing of Staging L0R Product for LPGS by ECS

According to modeling results from ECS, the average turnaround time for staging L0R data varies from 1/2 hour during the graveyard shift (the shift with the best turnaround time) to three hours during the second shift (the shift with the worst turnaround time). If the average turnaround time for staging a single L0R product is three hours, the turnaround time for some products could be much longer than three hours. This section is to examine the effects of the L0R turnaround time on the LPGS performance. In particular, it attempts to determine whether the LPGS can meet the workload of processing 28 scenes per day (25 required plus three reprocessed scenes) as a function of the turnaround time.

The analysis will be done for two scenarios: the normal scenario and the worst case scenario.

6.3.3.4.1 Normal Scenario (Best Case Scenario)

In the normal scenario, it is assumed that all the L0R products to be processed are one scene in size. Based on results from section 6.3.3.2, assuming that the average radiometric processing instruction takes two cycles to execute, it takes about 102 minutes to process four scenes with four processors. If the total number of scenes that can be held in the input buffer is 12, with four processors, it takes 306 minutes before running out of data for processing.

Therefore, as long as the turnaround time for L0R products is less than 306 minutes, none of the four processors needs to wait for data. This is the best case since the idle time is minimal.

The following equations show the average idle time and percent system idle time as a function of L0R turnaround time and input buffer size.

$$T_{\text{Average Idle}} = ((T_{\text{Turnaround time for L0R}}) - (T_{\text{WRS scene N}}) * (B_{\text{size}})/N) \quad \text{if } (T_{\text{Turnaround time for L0R}}) > (T_{\text{WRS scene N}}) * (B_{\text{Size}})/N$$

$$\text{or} \quad 0 \quad \text{if } (T_{\text{Turnaround time for L0R}}) <= (T_{\text{WRS scene N}}) * (B_{\text{Size}})/N$$

and

$$\%_{\text{System Idle}} = (T_{\text{Average Idle}}) / (T_{\text{Turnaround time for L0R}}) * 100\%$$

where

$T_{\text{Average Idle}}$:	Average idle time per processor
$T_{\text{Turnaround time for L0R}}$:	Turnaround time for L0R data
$T_{\text{WRS scene 1}}$:	Time to process one scene with one processor
$T_{\text{WRS scene N}}$:	Average time to process N scenes with N processors
B_{Size} :	Number of scenes that can be held in the input buffer
N:	Number of processors
$\%_{\text{System Idle}}$:	Percent of time the system is idle awaiting data to process.

Table 6-13 shows the average idle time ($T_{\text{Average Idle}}$) for a duration equal to the turnaround time as a function of the turnaround time and input buffer size. Table 6-14 shows the corresponding percent system idle time. Table 6-15 shows the number of scenes that can be processed per day assuming that processors are only 75 percent utilized. Even if the turnaround time is seven hours the LPGS can satisfy the required daily workload of retrieving, processing and transferring 25 scenes and reprocessing three scenes in the normal situation if the input buffer can hold 12 scenes.

Table 6–13. Average Idle Time (in hours) per Processor (best case)
(for a duration equal to turnaround time)
(workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
6	0.0	0.0	0.5	1.5	2.5	3.5	4.5	5.5	6.5
8	0.0	0.0	0.0	0.6	1.6	2.6	3.6	4.6	5.6
9	0.0	0.0	0.0	0.2	1.2	2.2	3.2	4.2	5.2
10	0.0	0.0	0.0	0.0	0.8	1.8	2.8	3.8	4.8
12	0.0	0.0	0.0	0.0	0.0	0.9	1.9	2.9	3.9
14	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.1	3.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.2	2.2

Table 6–14. Percent System Idle Time (best case)
(workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
6	0.0%	0.0%	15.0%	36.3%	49.0%	57.5%	63.6%	68.1%	71.7%
8	0.0%	0.0%	0.0%	15.0%	32.0%	43.3%	51.4%	57.5%	62.2%
9	0.0%	0.0%	0.0%	4.4%	23.5%	36.3%	45.4%	52.2%	57.5%
10	0.0%	0.0%	0.0%	0.0%	15.0%	29.2%	39.3%	46.9%	52.8%
12	0.0%	0.0%	0.0%	0.0%	0.0%	15.0%	27.1%	36.3%	43.3%
14	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	15.0%	25.6%	33.9%
16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.9%	15.0%	24.4%

Table 6–15. Number of Scenes that can be Processed per Day
(assuming 75 percent utilization) (best case)
(workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
6	42.4	42.4	36.0	27.0	21.6	18.0	15.4	13.5	12.0
8	42.4	42.4	42.4	36.0	28.8	24.0	20.6	18.0	16.0
9	42.4	42.4	42.4	40.5	32.4	27.0	23.1	20.3	18.0
10	42.4	42.4	42.4	42.4	36.0	30.0	25.7	22.5	20.0
12	42.4	42.4	42.4	42.4	42.4	36.0	30.9	27.0	24.0
14	42.4	42.4	42.4	42.4	42.4	42.0	36.0	31.5	28.0
16	42.4	42.4	42.4	42.4	42.4	42.4	41.1	36.0	32.0

The above results also apply to the situation where all L0R products to be processed are of the same size.

6.3.3.4.2 Worst Case Scenario

The results for the normal scenario are also true if the size of L0R products in the input buffer is larger than the size of the incoming L0R products yet to be staged by ECS. Under these situations, initiation of processing of a L0R product will allow for transferring of at least one L0R product from ECS. The input buffer can be kept close to the maximum level.

However due to the variations in L0R product size, even with very short turnaround time, some of the processor(s) will start to become idle once it has completed processing the last product request while the new L0R product has not yet arrived.

Considering the following simplified scenario:

- single processor
- the input buffer size is three scenes

- the last L0R product ($L0R_{last}$) in the input buffer is 1/2 scene in size
- the new L0R product ($L0R_{new}$) to be staged by ECS is three scenes in size.

To avoid overflow of the input buffer, the Acquire Request for the new L0R product ($L0R_{new}$, size = three scenes) can not be sent until the last L0R product ($L0R_{last}$, size = 1/2 scene) has begun to be processed. Even if the turnaround time is 2 hours, by the time the new L0R product ($L0R_{new}$) is available the processor has been idle for 69 minutes. (It takes 51 minutes to process one 1/2 scene of data.)

The above simplified example can be generalized to derive the "very" worst case scenario. The "very" worst case scenario occurs when all the L0R products in the input buffer are 1/2 scenes in size while all the L0R products waiting to be staged are three scenes in size.

Table 6-16 shows the total idle time ($T_{Total\ Idle}$) in processor-hours for the reference duration as a function of the turnaround time and input buffer size. The "reference duration" is defined as the time interval between the start of processing of the first old L0R product and the completion of staging of the last fourth new L0R product. The reference duration is used to measure the percent system idle time. Unlike the normal scenario, the reference duration varies depending on the buffer size and turnaround time.

Table 6-17 shows the corresponding percent system idle time. Table 6-18 shows the number of scenes that can be processed per day assuming that processors are only 75 percent utilized.

Under the worst case scenario, if the turnaround time is six hours the LPGS can still satisfy the required daily workload of retrieving, processing and transferring 25 scenes and reprocessing three scenes with the input buffer size of 12 scenes.

6.3.3.4.3 Summary

Table 6-15 and Table 6-18 summarize the two extreme cases (best case and worst case) for the number of WRS scenes that can be processed per day as a function of the turnaround time and input buffer size. From these two tables, it can be concluded that if the input buffer can hold 12 scenes, the requirement of retrieving, processing and transferring 28 scenes per day (including reprocessing of three scenes) can be met with a turnaround time of 6-7+ hours. Therefore if the average turnaround time is three hours the timing issue regarding the L0R product should not be a concern. To have a true "in-time" processing, the size of the input buffer should be kept small. If the size of the input buffer is reduced to nine scenes, the requirement can still be met with a turnaround time of 4-5+ hours.

Table 6–16. Total Idle Time (in processor-hours) (worst case) (for a duration equal to reference duration) (workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)							
(# of Scenes)	1	2	3	4	5	6	7	8
	Total Idle Time (processor-hours)							
6	2.6	8.1	13.2	19.6	26.4	31.0	37.4	42.5
9	0.9	3.4	6.4	11.7	17.3	21.3	26.6	30.8
12	0.4	1.5	3.2	6.4	10.8	14.0	18.3	21.7
15	0.0	0.0	0.9	2.8	5.9	8.9	13.2	16.6
	Reference Duration (hours)							
6	4.6	6.7	8.5	10.6	12.8	14.5	16.7	18.4
9	5.0	6.1	7.2	9.3	11.5	13.2	15.4	17.1
12	6.3	7.2	8.0	9.1	10.2	11.1	12.1	13.0
15	7.2	7.2	8.0	9.1	10.2	11.1	12.1	13.0

Table 6–17. Percent System Idle Time (worst case) (workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)							
(# of Scenes)	1	2	3	4	5	6	7	8
6	14.0%	30.1%	39.0%	46.0%	51.7%	53.4%	56.0%	57.7%
9	4.3%	14.0%	22.3%	31.4%	37.7%	40.2%	43.2%	45.0%
12	1.7%	5.2%	9.9%	17.5%	26.6%	31.7%	37.6%	41.7%
15	0.0%	0.0%	2.6%	7.6%	14.4%	20.2%	27.1%	31.9%

Table 6–18. Number of WRS Scenes that can be Processed per Day (worst case) (assuming 75 percent utilization) (workload = 25+ 3 scenes/day)

Input Buffer Size	Turnaround Time (hours)							
(# of Scenes)	1	2	3	4	5	6	7	8
6	36.4	29.6	25.8	22.9	20.5	19.7	18.6	17.9
9	40.5	36.4	32.9	29.1	26.4	25.3	24.1	23.3
12	41.6	40.1	38.1	34.9	31.1	28.9	26.4	24.7
15	42.4	42.4	41.2	39.1	36.3	33.8	30.9	28.8

6.3.4 Workload 2 - 50 Scenes per Day

To process 50 scenes per day, the following assumptions are used (refer to Table 6-7):

- nominal processing of 50 scenes per day
- reprocessing of six scenes per day
- anomaly analysis of three scenes per day
- eight CPUs
- processing eight requests simultaneously
- 10-percent performance degradation for CPUs
- eight RAIDs partitioned into two groups.

6.3.4.1 Service Time

The service time for nominal processing of different scene sizes with a 10-percent CPU performance degradation factor is shown in Table 6-19. The service time is estimated assuming two CPU cycles to execute an average instruction for the radiometric processing. Actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-19.

Table 6-20 shows the service time with various assumptions on the number of CPU cycles for average radiometric processing instructions for different scene sizes. Similar to Table 6-19, actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-20.

6.3.4.2 System Throughput

To fully utilize the available resources, in particular CPUs, eight product requests will be processed simultaneously. For the worst case average scene, the total service time for one scene is 99.53 minutes assuming that the average radiometric processing instructions will take two CPU cycles to execute. However, due to the possible I/O contention among the eight product requests, it will take more than 99.53 minutes to process eight scenes with eight CPUs. The time it takes to nominally process eight scenes using eight CPUs as a function of the number of cycles for average instructions is shown in Table 6-21. The eight RAIDs are partitioned into two groups, with each group having files associated with four of the eight product requests being processed. The disk I/O contention exists among the files residing on the same RAID group, but does not exist among files residing on different RAID groups. The processing time is estimated based on the probability of the disk being busy serving other product requests on the same RAID group. It is assumed that the contention on the FDDI does not have effects on the processing time because the FDDI data transfer occurs prior to and after processing. Assuming that the system is 75% utilized, the amount of time it takes to process the required daily workload and the maximum number of scenes that can be processed each day are also shown in Table 6-21. Note that Table 6-21 only covers the nominal processing (including reprocessing). It does not cover the anomaly analysis.

Table 6–19. Service Time for Different Scene Sizes (workload = 50 + 5 scenes/day)

8-CPU Configuration (CPU Performance Degradation Factor = 10%) (Time in minutes)							
Scene Size	Activity	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
1/2	**CPU Time**						
WRS	Application	negligible	28.93	16.66	negligible	negligible	45.59
Scene	Overhead associated with FDDI data transfer	0.14	0.00	0.00	0.00	0.27	0.40
(actual)	Overhead associated with RAID data transfer	0.16	1.05	0.52	0.31	0.10	2.13
	Subtotal	0.29	29.97	17.18	0.31	0.37	48.12
	Data Transfer Time						
	FDDI	0.61	0.00	0.00	0.00	1.21	1.82
	RAID	0.20	1.31	0.65	0.39	0.13	2.67
	Subtotal	0.80	1.31	0.65	0.39	1.34	4.49
	Total	1.10	31.29	17.83	0.70	1.71	52.61
1	**CPU Time**						
WRS	Application	negligible	51.84	33.33	negligible	negligible	85.17
Scene	Overhead associated with FDDI data transfer	0.26	0.00	0.00	0.00	0.53	0.80
(actual)	Overhead associated with RAID data transfer	0.31	2.09	0.96	0.53	0.17	4.05
	Subtotal	0.57	53.93	34.28	0.53	0.71	90.02
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.39	3.58
	RAID	0.38	2.62	1.20	0.66	0.22	5.08
	Subtotal	1.57	2.62	1.20	0.66	2.61	8.66
	Total	2.14	56.54	35.49	1.19	3.32	98.68
2	**CPU Time**						
WRS	Application	negligible	97.68	66.65	negligible	negligible	164.33
Scenes	Overhead associated with FDDI data transfer	0.52	0.00	0.00	0.00	1.06	1.58
(actual)	Overhead associated with RAID data transfer	0.60	4.16	1.96	1.14	0.38	8.24
	Subtotal	1.13	101.84	68.61	1.14	1.43	174.15
	Data Transfer Time						
	FDDI	2.35	0.00	0.00	0.00	4.75	7.11
	RAID	0.76	5.22	2.46	1.43	0.47	10.33
	Subtotal	3.11	5.22	2.46	1.43	5.23	17.44
	Total	4.24	107.06	71.07	2.57	6.66	191.59
3	**CPU Time**						
WRS	Application	negligible	143.51	99.98	negligible	negligible	243.48
Scenes	Overhead associated with FDDI data transfer	0.78	0.00	0.00	0.00	1.71	2.49
(actual)	Overhead associated with RAID data transfer	0.90	6.24	3.11	1.98	0.66	12.89
	Subtotal	1.68	149.75	103.09	1.98	2.37	258.87
	Data Transfer Time						
	FDDI	3.52	0.00	0.00	0.00	7.69	11.20
	RAID	1.13	7.82	3.90	2.48	0.82	16.16
	Subtotal	4.65	7.82	3.90	2.48	8.51	27.36
	Total	6.33	157.57	106.99	4.46	10.88	286.23
1	**CPU Time**						
WRS	Application	negligible	51.84	33.33	negligible	negligible	85.17
Scene	Overhead associated with FDDI data transfer	0.26	0.00	0.00	0.00	0.57	0.84
(average)	Overhead associated with RAID data transfer	0.31	2.09	1.05	0.66	0.22	4.33
	Subtotal	0.57	53.93	34.38	0.66	0.79	90.33
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.58	3.77
	RAID	0.38	2.62	1.32	0.83	0.28	5.42
	Subtotal	1.57	2.62	1.32	0.83	2.86	9.19
	Total	2.14	56.54	35.69	1.50	3.65	99.53

Table 6–20. Service Time for Different Scene Sizes as a Function of CPU Cycles per Instruction (workload = 50 + 5 scenes/day)

8-CPU Configuration (CPU Performance Degradation Factor = 10%) (Time in minutes)						
Scene	**# of Cycles/Instruction**	1	2	3	4	5
Size	**Equivalent MFLOP**	195	97.5	65	48.75	39
1/2	**CPU Time**					
WRS	Application	31.13	45.59	60.05	74.51	88.98
Scene	Overhead associated with FDDI data transfer	0.40	0.40	0.40	0.40	0.40
(actual)	Overhead associated with RAID data transfer	2.13	2.13	2.13	2.13	2.13
	Subtotal	33.66	48.12	62.59	77.05	91.51
	Data Transfer Time					
	FDDI	1.82	1.82	1.82	1.82	1.82
	RAID	2.67	2.67	2.67	2.67	2.67
	Subtotal	4.49	4.49	4.49	4.49	4.49
	Total	38.15	52.61	67.08	81.54	96.00
1	**CPU Time**					
WRS	Application	59.25	85.17	111.09	137.01	162.93
Scene	Overhead associated with FDDI data transfer	0.80	0.80	0.80	0.80	0.80
(actual)	Overhead associated with RAID data transfer	4.05	4.05	4.05	4.05	4.05
	Subtotal	64.10	90.02	115.94	141.86	167.78
	Data Transfer Time					
	FDDI	3.58	3.58	3.58	3.58	3.58
	RAID	5.08	5.08	5.08	5.08	5.08
	Subtotal	8.66	8.66	8.66	8.66	8.66
	Total	72.76	98.68	124.60	150.52	176.44
2	**CPU Time**					
WRS	Application	115.49	164.33	213.16	262.00	310.84
Scenes	Overhead associated with FDDI data transfer	1.58	1.58	1.58	1.58	1.58
(actual)	Overhead associated with RAID data transfer	8.24	8.24	8.24	8.24	8.24
	Subtotal	125.31	174.15	222.99	271.83	320.66
	Data Transfer Time					
	FDDI	7.11	7.11	7.11	7.11	7.11
	RAID	10.33	10.33	10.33	10.33	10.33
	Subtotal	17.44	17.44	17.44	17.44	17.44
	Total	142.75	191.59	240.43	289.26	338.10
3	**CPU Time**					
WRS	Application	171.73	243.48	315.24	386.99	458.75
Scenes	Overhead associated with FDDI data transfer	2.49	2.49	2.49	2.49	2.49
(actual)	Overhead associated with RAID data transfer	12.89	12.89	12.89	12.89	12.89
	Subtotal	187.11	258.87	330.62	402.38	474.13
	Data Transfer Time					
	FDDI	11.20	11.20	11.20	11.20	11.20
	RAID	16.16	16.16	16.16	16.16	16.16
	Subtotal	27.36	27.36	27.36	27.36	27.36
	Total	214.48	286.23	357.99	429.74	501.50
1	**CPU Time**					
WRS	Application	59.25	85.17	111.09	137.01	162.93
Scene	Overhead associated with FDDI data transfer	0.84	0.84	0.84	0.84	0.84
(average)	Overhead associated with RAID data transfer	4.33	4.33	4.33	4.33	4.33
	Subtotal	64.41	90.33	116.25	142.18	168.10
	Data Transfer Time					
	FDDI	3.77	3.77	3.77	3.77	3.77
	RAID	5.42	5.42	5.42	5.42	5.42
	Subtotal	9.19	9.19	9.19	9.19	9.19
	Total	73.61	99.53	125.45	151.37	177.29

Table 6–21. System Throughput Using Eight CPUs (workload = 50 + 5 scenes/day)

8-CPU Configuration (CPU Performance Degradation Factor = 10%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Time to process 8 WRS scenes Using 8 CPUs (minutes)	85.15	108.92	133.33	158.15	183.24
Maximum daily throughput (scenes/day)	101	79	64	54 **	47 **
Time to process 50 scenes + reprocess 5 scenes (hours)	9.8	12.5	15.3	18.2	21
** : can not support the required workload with the assumption that the system can only be 75% utilized					

6.3.4.3 Resource Utilization

6.3.4.3.1 CPU, FDDI, and Disk I/O

Table 6-22 shows the CPU, FDDI and disk I/O utilization as a function of the number of cycles for average instructions over a period of 24 hours. The worst case average scene size is used in the utilization calculation. Separate values are provided for nominal processing with and without non-nominal processing (anomaly analysis).

Figure 6-3 shows the CPU utilization over a 24-hour period for nominal processing of 50 scenes and reprocessing of five scenes using eight CPUs as a function of CPU cycles per average instruction and actual scene size. Figure 6-4 shows the similar CPU utilization with anomaly analysis of three scenes added. Figure 6-4 shows that the CPUs can be kept less than 75 percent utilized; even the radiometric processing software only achieves 65 MFLOPS (three cycles per instruction). For nominal processing only, the CPU utilization is higher than the CPU utilization for workload 1. However, for nominal processing and non-nominal processing, the CPU utilization is lower than the CPU utilization for workload 1 because the number of scenes that need to be analyzed for anomalies remains the same while the number of CPUs increases for this workload.

6.3.4.3.2 Disk Storage

The disk storage utilization is shown in Table 6-8.

6.3.4.3.3 Memory Requirements

The memory required to process each band of data for different scene sizes is shown in Table 6-5.

Table 6–22. Resource Utilization over a 24-Hour Period (workload = 50 + 5 scenes/day)

8-CPU Configuration (CPU Performance Degradation Factor = 10%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Nominal processing & non-nominal processing					
CPU	34.35%	48.08%	61.81%	75.53%	89.26%
FDDI data transfer	22.40%	22.40%	22.40%	22.40%	22.40%
Disk I/O	11.83%	11.83%	11.83%	11.83%	11.83%
Nominal processing only					
CPU	30.75%	43.13%	55.50%	67.88%	80.25%
FDDI data transfer	14.40%	14.40%	14.40%	14.40%	14.40%
Disk I/O	10.36%	10.36%	10.36%	10.36%	10.36%

Figure 6–3. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Nominal Processing Only) (workload = 50 + 5 scenes per day)

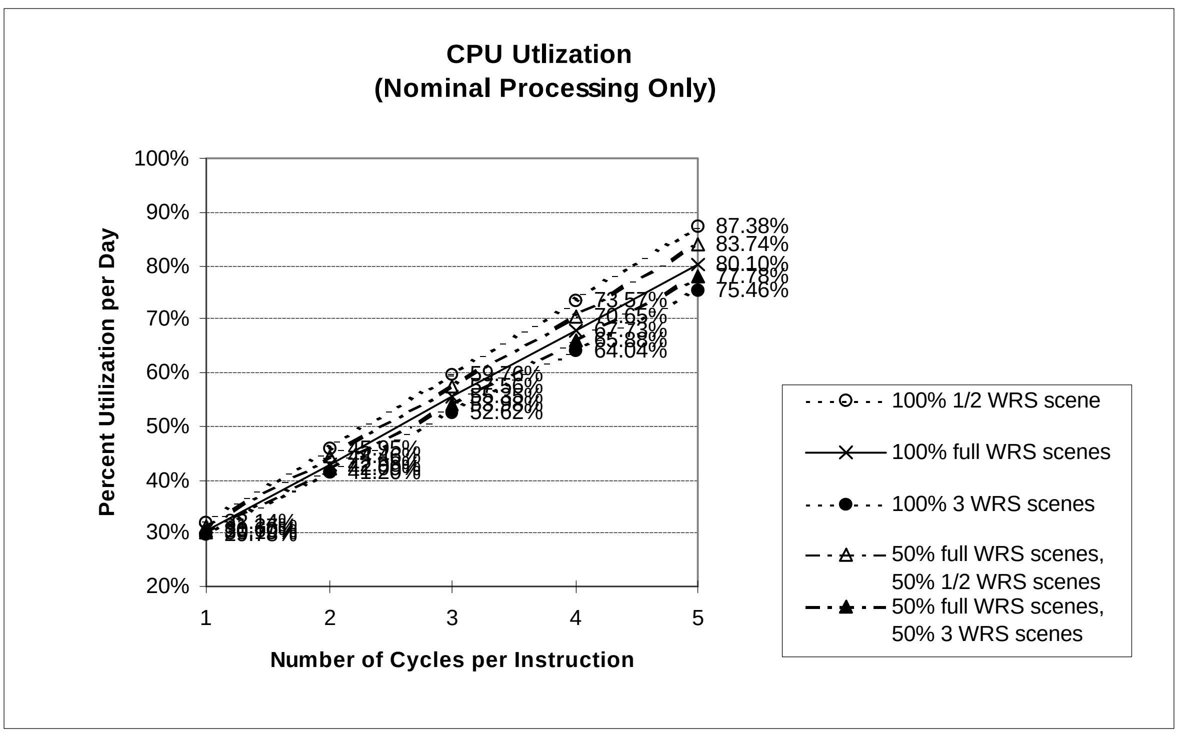
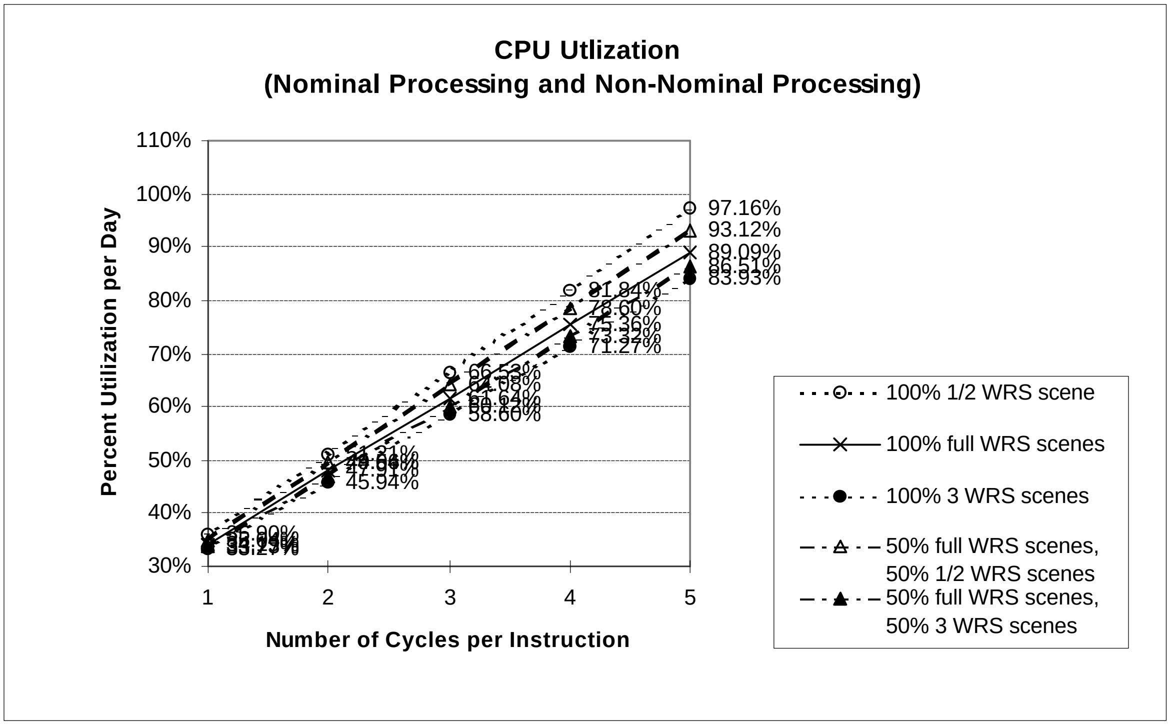


Figure 6–4. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Including Non-nominal Processing) (workload = 50 + 5 scenes per day)



6.3.5 Workload 3 - 75 Scenes per Day

To process 75 scenes per day, the following assumptions are used (refer to Table 6-7):

- nominal processing of 75 scenes per day
- reprocessing of eight scenes per day
- anomaly analysis of six scenes per day
- 12 CPUs
- processing 12 requests simultaneously
- 12-percent performance degradation for CPUs
- 12 RAIDs partitioned into three groups.

6.3.5.1 Service Time

The service time for nominal processing of different scene sizes with a 12-percent CPU performance degradation factor is shown in Table 6-23. The service time is estimated assuming two CPU cycles to execute an average instruction for the radiometric processing. Actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-23.

Table 6-24 shows the service time with various assumptions on the number of CPU cycles for average radiometric processing instructions for different scene sizes. Similar to Table 6-23, actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-24.

6.3.5.2 System Throughput

To fully utilize the available resources, in particular CPUs, 12 product requests will be processed simultaneously. For the worst case average scene, the total service time for one scene is 101.58 minutes assuming that the average radiometric processing instructions will take two CPU cycles to execute. However, due to the possible I/O contention among the 12 product requests, it will take more than 101.58 minutes to process 12 scenes with 12 CPUs. The time it takes to nominally process 12 scenes using 12 CPUs as a function of the number of cycles for average instructions is shown in Table 6-25. The 12 RAIDs are partitioned into three groups, with each group having files associated with four of the 12 product requests being processed. The disk I/O contention exists among the files residing on the same RAID group, but does not exist among files residing on different RAID groups. The processing time is estimated based on the probability of the disk being busy serving other product requests on the same RAID group. It is assumed that the contention on the FDDI does not have effects on the processing time because the FDDI data transfer occurs prior to and after processing. Assuming that the system is 75% utilized, the amount of time it takes to process the required daily workload and the maximum number of scenes that can be processed each day are also shown in Table 6-25. Note that Table 6-25 only covers the nominal processing (including reprocessing). It does not cover the anomaly analysis.

Table 6–23. Service Time for Different Scene Sizes (workload = 75 + 8 scenes/day)

12-CPU Configuration (CPU Performance Degradation Factor = 12%) (Time in minutes)							
Scene Size	Activity	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
1/2 WRS Scene (actual)	**CPU Time**						
	Application	negligible	29.58	17.04	negligible	negligible	46.62
	Overhead associated with FDDI data transfer	0.14	0.00	0.00	0.00	0.28	0.41
	Overhead associated with RAID data transfer	0.16	1.07	0.53	0.32	0.10	2.18
	Subtotal	0.30	30.65	17.57	0.32	0.38	49.22
	Data Transfer Time						
	FDDI	0.61	0.00	0.00	0.00	1.21	1.82
	RAID	0.20	1.31	0.65	0.39	0.13	2.67
	Subtotal	0.80	1.31	0.65	0.39	1.34	4.49
	Total	1.10	31.97	18.22	0.70	1.72	53.71
1 WRS Scene (actual)	**CPU Time**						
	Application	negligible	53.02	34.08	negligible	negligible	87.10
	Overhead associated with FDDI data transfer	0.27	0.00	0.00	0.00	0.54	0.81
	Overhead associated with RAID data transfer	0.31	2.13	0.98	0.54	0.18	4.15
	Subtotal	0.58	55.15	35.06	0.54	0.72	92.06
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.39	3.58
	RAID	0.38	2.62	1.20	0.66	0.22	5.08
	Subtotal	1.57	2.62	1.20	0.66	2.61	8.66
	Total	2.16	57.77	36.27	1.20	3.33	100.73
2 WRS Scenes (actual)	**CPU Time**						
	Application	negligible	99.90	68.16	negligible	negligible	168.06
	Overhead associated with FDDI data transfer	0.54	0.00	0.00	0.00	1.08	1.62
	Overhead associated with RAID data transfer	0.62	4.26	2.00	1.16	0.39	8.43
	Subtotal	1.15	104.15	70.17	1.16	1.47	178.11
	Data Transfer Time						
	FDDI	2.35	0.00	0.00	0.00	4.75	7.11
	RAID	0.76	5.22	2.46	1.43	0.47	10.33
	Subtotal	3.11	5.22	2.46	1.43	5.23	17.44
	Total	4.26	109.37	72.63	2.59	6.69	195.55
3 WRS Scenes (actual)	**CPU Time**						
	Application	negligible	146.77	102.25	negligible	negligible	249.02
	Overhead associated with FDDI data transfer	0.80	0.00	0.00	0.00	1.75	2.55
	Overhead associated with RAID data transfer	0.92	6.38	3.18	2.02	0.67	13.19
	Subtotal	1.72	153.15	105.43	2.02	2.42	264.75
	Data Transfer Time						
	FDDI	3.52	0.00	0.00	0.00	7.69	11.20
	RAID	1.13	7.82	3.90	2.48	0.82	16.16
	Subtotal	4.65	7.82	3.90	2.48	8.51	27.36
	Total	6.37	160.98	109.33	4.51	10.93	292.12
1 WRS Scene (average)	**CPU Time**						
	Application	negligible	53.02	34.08	negligible	negligible	87.10
	Overhead associated with FDDI data transfer	0.27	0.00	0.00	0.00	0.59	0.86
	Overhead associated with RAID data transfer	0.31	2.13	1.07	0.68	0.23	4.43
	Subtotal	0.58	55.15	35.16	0.68	0.81	92.39
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.58	3.77
	RAID	0.38	2.62	1.32	0.83	0.28	5.42
	Subtotal	1.57	2.62	1.32	0.83	2.86	9.19
	Total	2.16	57.77	36.47	1.51	3.67	101.58

Table 6–24. Service Time for Different Scene Sizes as a Function of CPU Cycles per Instruction (workload = 75 + 8 scenes/day)

12-CPU Configuration (CPU Performance Degradation Factor = 12%) (Time in minutes)						
Scene	**# of Cycles/Instruction**	1	2	3	4	5
Size	**Equivalent MFLOP**	195	97.5	65	48.75	39
1/2	**CPU Time**					
WRS	Application	31.83	46.62	61.42	76.21	91.00
Scene	Overhead associated with FDDI data transfer	0.41	0.41	0.41	0.41	0.41
(actual)	Overhead associated with RAID data transfer	2.18	2.18	2.18	2.18	2.18
	Subtotal	34.43	49.22	64.01	78.80	93.59
	Data Transfer Time					
	FDDI	1.82	1.82	1.82	1.82	1.82
	RAID	2.67	2.67	2.67	2.67	2.67
	Subtotal	4.49	4.49	4.49	4.49	4.49
	Total	38.92	53.71	68.50	83.29	98.08
1	**CPU Time**					
WRS	Application	60.59	87.10	113.61	140.12	166.63
Scene	Overhead associated with FDDI data transfer	0.81	0.81	0.81	0.81	0.81
(actual)	Overhead associated with RAID data transfer	4.15	4.15	4.15	4.15	4.15
	Subtotal	65.55	92.06	118.57	145.08	171.59
	Data Transfer Time					
	FDDI	3.58	3.58	3.58	3.58	3.58
	RAID	5.08	5.08	5.08	5.08	5.08
	Subtotal	8.66	8.66	8.66	8.66	8.66
	Total	74.22	100.73	127.24	153.75	180.26
2	**CPU Time**					
WRS	Application	118.11	168.06	218.01	267.96	317.90
Scenes	Overhead associated with FDDI data transfer	1.62	1.62	1.62	1.62	1.62
(actual)	Overhead associated with RAID data transfer	8.43	8.43	8.43	8.43	8.43
	Subtotal	128.16	178.11	228.06	278.00	327.95
	Data Transfer Time					
	FDDI	7.11	7.11	7.11	7.11	7.11
	RAID	10.33	10.33	10.33	10.33	10.33
	Subtotal	17.44	17.44	17.44	17.44	17.44
	Total	145.60	195.55	245.49	295.44	345.39
3	**CPU Time**					
WRS	Application	175.63	249.02	322.40	395.79	469.17
Scenes	Overhead associated with FDDI data transfer	2.55	2.55	2.55	2.55	2.55
(actual)	Overhead associated with RAID data transfer	13.19	13.19	13.19	13.19	13.19
	Subtotal	191.37	264.75	338.14	411.52	484.91
	Data Transfer Time					
	FDDI	11.20	11.20	11.20	11.20	11.20
	RAID	16.16	16.16	16.16	16.16	16.16
	Subtotal	27.36	27.36	27.36	27.36	27.36
	Total	218.73	292.12	365.50	438.89	512.27
1	**CPU Time**					
WRS	Application	60.59	87.10	113.61	140.12	166.63
Scene	Overhead associated with FDDI data transfer	0.86	0.86	0.86	0.86	0.86
(average)	Overhead associated with RAID data transfer	4.43	4.43	4.43	4.43	4.43
	Subtotal	65.88	92.39	118.90	145.41	171.92
	Data Transfer Time					
	FDDI	3.77	3.77	3.77	3.77	3.77
	RAID	5.42	5.42	5.42	5.42	5.42
	Subtotal	9.19	9.19	9.19	9.19	9.19
	Total	75.07	101.58	128.09	154.60	181.11

Table 6–25. System Throughput Using 12 CPUs (workload = 75 + 8 scenes/day)

12-CPU Configuration (CPU Performance Degradation Factor = 12%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Time to process 12 WRS scenes Using 12 CPUs (minutes)	89.94	114.17	138.93	164.09	189.54
Maximum daily throughput (scenes/day)	144	113	93	78 **	68 **
Time to process 75 scenes + reprocess 8 scenes (hours)	10.4	13.2	16.1	19	21.9
** : can not support the required workload with the assumption that the system can only be 75% utilized					

6.3.5.3 Resource Utilization

6.3.5.3.1 CPU, FDDI, and Disk I/O

Table 6-26 shows the CPU, FDDI and disk I/O utilization as a function of the number of cycles for average instructions over a period of 24 hours. The worst case average scene size is used in the utilization calculation. Separate values are provided for nominal processing with and without non-nominal processing (anomaly analysis).

Figure 6-5 shows the CPU utilization over a 24-hour period for nominal processing of 75 scenes and reprocessing of eight scenes using 12 CPUs as a function of CPU cycles per average instruction and actual scene size. Figure 6-6 shows the similar CPU utilization with anomaly analysis of six scenes added. Figure 6-6 shows that the CPUs can be kept less than 75 percent utilized; even the radiometric processing software only achieves 65 MFLOPS (three cycles per instruction).

6.3.5.3.2 Disk Storage

The disk storage utilization is shown in Table 6-8.

6.3.5.3.3 Memory Requirements

The memory required to process each band of data for different scene sizes is shown in Table 6-5.

Table 6–26. Resource Utilization over a 24-Hour Period (workload = 75 + 8 scenes/day)

12-CPU Configuration (CPU Performance Degradation Factor = 12%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Nominal processing & non-nominal processing					
CPU	36.55%	51.13%	65.70%	80.28%	94.85%
FDDI data transfer	37.72%	37.72%	37.72%	37.72%	37.72%
Disk I/O	12.39%	12.39%	12.39%	12.39%	12.39%
Nominal processing only					
CPU	31.64%	44.38%	57.11%	69.84%	82.58%
FDDI data transfer	21.73%	21.73%	21.73%	21.73%	21.73%
Disk I/O	10.42%	10.42%	10.42%	10.42%	10.42%

Figure 6–5. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Nominal Processing Only) (workload = 75 + 8 scenes per day)

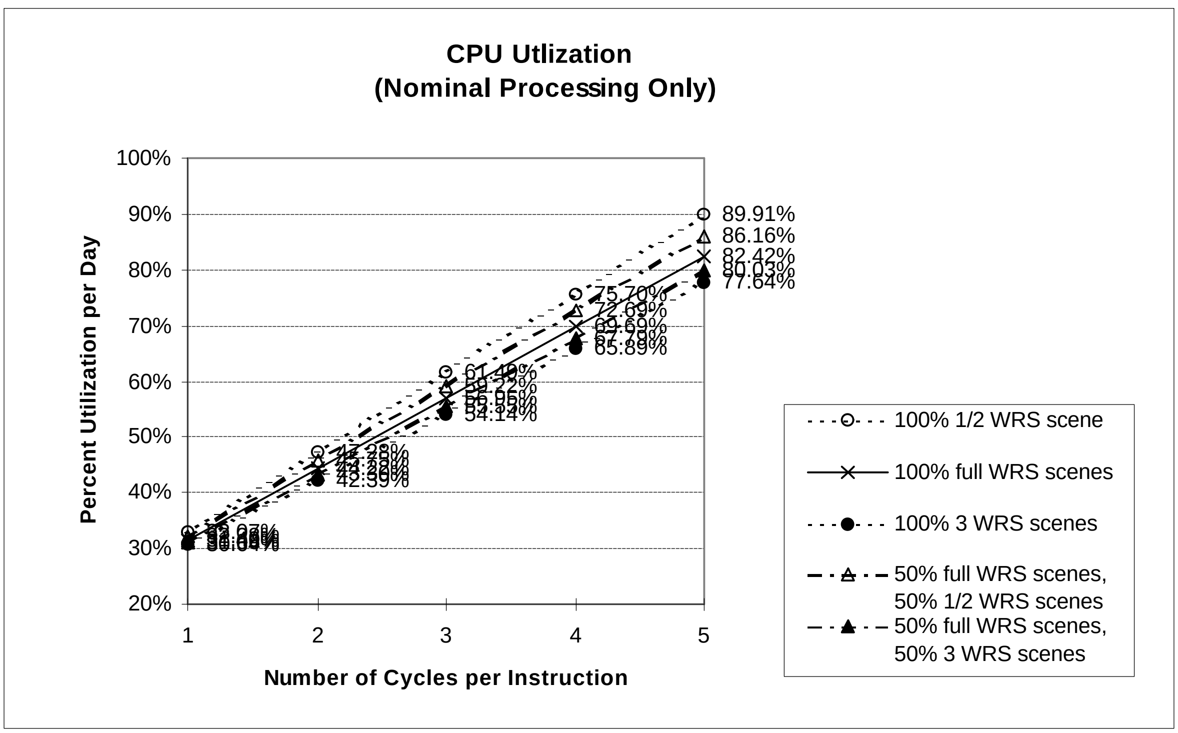
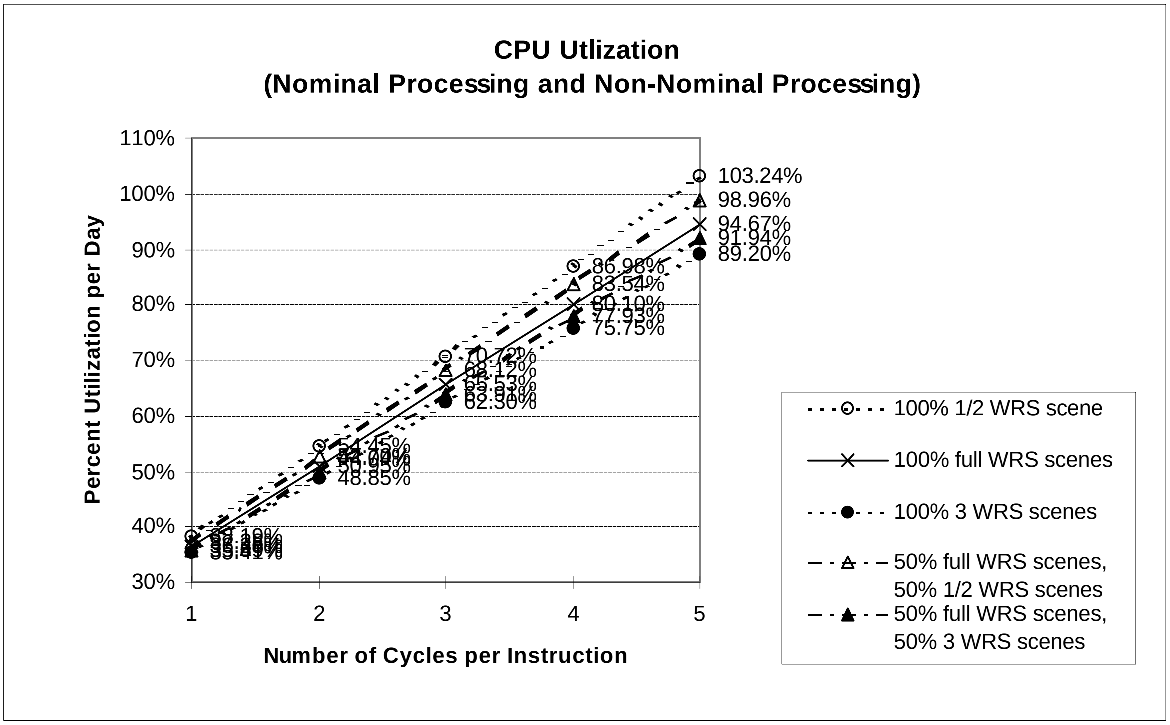


Figure 6–6. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Including Non-nominal Processing) (workload = 75 + 8 scenes per day)



6.3.6 Workload 4 - 100 Scenes per Day

To process 100 scenes per day, the following assumptions are used (refer to Table 6-7):

- nominal processing of 100 scenes per day
- reprocessing of 10 scenes per day
- anomaly analysis of six scenes per day
- 16 CPUs
- processing 16 requests simultaneously
- 14-percent performance degradation for CPUs
- 16 RAIDs partitioned into four groups.

6.3.6.1 Service Time

The service time for nominal processing of different scene sizes with a 14-percent CPU performance degradation factor is shown in Table 6-27. The service time is estimated assuming two CPU cycles to execute an average instruction for the radiometric processing. Actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-27.

Table 6-28 shows the service time with various assumptions on the number of CPU cycles for average radiometric processing instructions for different scene sizes. Similar to Table 6-27, actual scene sizes are used in the service time estimation. In addition, the service time for the worst case average size of one full scene is also included in Table 6-28.

6.3.6.2 System Throughput

To fully utilize the available resources, in particular CPUs, 16 product requests will be processed simultaneously. For the worst case average scene, the total service time for one scene is 103.73 minutes assuming that the average radiometric processing instructions will take two CPU cycles to execute. However, due to the possible I/O contention among the 16 product requests, it will take more than 103.73 minutes to process 16 scenes with 16 CPUs. The time it takes to nominally process 16 scenes using 16 CPUs as a function of the number of cycles for average instructions is shown in Table 6-29. The 16 RAIDs are partitioned into four groups, with each group having files associated with four of the 16 product requests being processed. The disk I/O contention exists among the files residing on the same RAID group, but does not exist among files residing on different RAID groups. The processing time is estimated based on the probability of the disk being busy serving other product requests on the same RAID group. It is assumed that the contention on the FDDI does not have effects on the processing time because the FDDI data transfer occurs prior to and after processing. Assuming that the system is 75% utilized, the amount of time it takes to process the required daily workload and the maximum number of scenes that can be processed each day are also shown in Table 6-29. Note that Table 6-29 only covers the nominal processing (including reprocessing). It does not cover the anomaly analysis.

Table 6–27. Service Time for Different Scene Sizes (workload = 100 + 10 scenes/day)

16-CPU Configuration (CPU Performance Degradation Factor = 14%) (Time in minutes)							
Scene Size	Activity	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
1/2	**CPU Time**						
WRS	Application	negligible	30.27	17.44	negligible	negligible	47.71
Scene	Overhead associated with FDDI data transfer	0.14	0.00	0.00	0.00	0.28	0.42
(actual)	Overhead associated with RAID data transfer	0.16	1.10	0.54	0.32	0.11	2.23
	Subtotal	0.31	31.37	17.98	0.32	0.39	50.36
	Data Transfer Time						
	FDDI	0.61	0.00	0.00	0.00	1.21	1.82
	RAID	0.20	1.31	0.65	0.39	0.13	2.67
	Subtotal	0.80	1.31	0.65	0.39	1.34	4.49
	Total	1.11	32.68	18.63	0.71	1.73	54.85
1	**CPU Time**						
WRS	Application	negligible	54.25	34.88	negligible	negligible	89.13
Scene	Overhead associated with FDDI data transfer	0.28	0.00	0.00	0.00	0.56	0.83
(actual)	Overhead associated with RAID data transfer	0.32	2.18	1.00	0.55	0.18	4.24
	Subtotal	0.60	56.44	35.88	0.55	0.74	94.20
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.39	3.58
	RAID	0.38	2.62	1.20	0.66	0.22	5.08
	Subtotal	1.57	2.62	1.20	0.66	2.61	8.66
	Total	2.17	59.05	37.08	1.21	3.35	102.87
2	**CPU Time**						
WRS	Application	negligible	102.22	69.75	negligible	negligible	171.97
Scenes	Overhead associated with FDDI data transfer	0.55	0.00	0.00	0.00	1.11	1.65
(actual)	Overhead associated with RAID data transfer	0.63	4.36	2.05	1.19	0.40	8.63
	Subtotal	1.18	106.58	71.80	1.19	1.50	182.25
	Data Transfer Time						
	FDDI	2.35	0.00	0.00	0.00	4.75	7.11
	RAID	0.76	5.22	2.46	1.43	0.47	10.33
	Subtotal	3.11	5.22	2.46	1.43	5.23	17.44
	Total	4.29	111.79	74.26	2.62	6.73	199.69
3	**CPU Time**						
WRS	Application	negligible	150.18	104.63	negligible	negligible	254.81
Scenes	Overhead associated with FDDI data transfer	0.82	0.00	0.00	0.00	1.79	2.61
(actual)	Overhead associated with RAID data transfer	0.94	6.53	3.26	2.07	0.69	13.49
	Subtotal	1.76	156.71	107.88	2.07	2.48	270.91
	Data Transfer Time						
	FDDI	3.52	0.00	0.00	0.00	7.69	11.20
	RAID	1.13	7.82	3.90	2.48	0.82	16.16
	Subtotal	4.65	7.82	3.90	2.48	8.51	27.36
	Total	6.41	164.54	111.79	4.55	10.99	298.27
1	**CPU Time**						
WRS	Application	negligible	54.25	34.88	negligible	negligible	89.13
Scene	Overhead associated with FDDI data transfer	0.28	0.00	0.00	0.00	0.60	0.88
(average)	Overhead associated with RAID data transfer	0.32	2.18	1.10	0.70	0.23	4.53
	Subtotal	0.60	56.44	35.97	0.70	0.83	94.53
	Data Transfer Time						
	FDDI	1.19	0.00	0.00	0.00	2.58	3.77
	RAID	0.38	2.62	1.32	0.83	0.28	5.42
	Subtotal	1.57	2.62	1.32	0.83	2.86	9.19
	Total	2.17	59.05	37.29	1.53	3.69	103.73

Table 6–28. Service Time for Different Scene Sizes as a Function of CPU Cycles per Instruction (workload = 100 + 10 scenes/day)

16-CPU Configuration (CPU Performance Degradation Factor = 14%) (Time in minutes)						
Scene	**# of Cycles/Instruction**	1	2	3	4	5
Size	**Equivalent MFLOP**	195	97.5	65	48.75	39
1/2	**CPU Time**					
WRS	Application	32.57	47.71	62.84	77.98	93.11
Scene	Overhead associated with FDDI data transfer	0.42	0.42	0.42	0.42	0.42
(actual)	Overhead associated with RAID data transfer	2.23	2.23	2.23	2.23	2.23
	Subtotal	35.23	50.36	65.50	80.63	95.77
	Data Transfer Time					
	FDDI	1.82	1.82	1.82	1.82	1.82
	RAID	2.67	2.67	2.67	2.67	2.67
	Subtotal	4.49	4.49	4.49	4.49	4.49
	Total	39.72	54.85	69.99	85.12	100.26
1	**CPU Time**					
WRS	Application	62.00	89.13	116.25	143.38	170.51
Scene	Overhead associated with FDDI data transfer	0.83	0.83	0.83	0.83	0.83
(actual)	Overhead associated with RAID data transfer	4.24	4.24	4.24	4.24	4.24
	Subtotal	67.08	94.20	121.33	148.46	175.58
	Data Transfer Time					
	FDDI	3.58	3.58	3.58	3.58	3.58
	RAID	5.08	5.08	5.08	5.08	5.08
	Subtotal	8.66	8.66	8.66	8.66	8.66
	Total	75.74	102.87	129.99	157.12	184.25
2	**CPU Time**					
WRS	Application	120.86	171.97	223.08	274.19	325.30
Scenes	Overhead associated with FDDI data transfer	1.65	1.65	1.65	1.65	1.65
(actual)	Overhead associated with RAID data transfer	8.63	8.63	8.63	8.63	8.63
	Subtotal	131.14	182.25	233.36	284.47	335.58
	Data Transfer Time					
	FDDI	7.11	7.11	7.11	7.11	7.11
	RAID	10.33	10.33	10.33	10.33	10.33
	Subtotal	17.44	17.44	17.44	17.44	17.44
	Total	148.58	199.69	250.80	301.91	353.02
3	**CPU Time**					
WRS	Application	179.72	254.81	329.90	404.99	480.09
Scenes	Overhead associated with FDDI data transfer	2.61	2.61	2.61	2.61	2.61
(actual)	Overhead associated with RAID data transfer	13.49	13.49	13.49	13.49	13.49
	Subtotal	195.82	270.91	346.00	421.09	496.19
	Data Transfer Time					
	FDDI	11.20	11.20	11.20	11.20	11.20
	RAID	16.16	16.16	16.16	16.16	16.16
	Subtotal	27.36	27.36	27.36	27.36	27.36
	Total	223.18	298.27	373.37	448.46	523.55
1	**CPU Time**					
WRS	Application	62.00	89.13	116.25	143.38	170.51
Scene	Overhead associated with FDDI data transfer	0.88	0.88	0.88	0.88	0.88
(average)	Overhead associated with RAID data transfer	4.53	4.53	4.53	4.53	4.53
	Subtotal	67.41	94.53	121.66	148.79	175.91
	Data Transfer Time					
	FDDI	3.77	3.77	3.77	3.77	3.77
	RAID	5.42	5.42	5.42	5.42	5.42
	Subtotal	9.19	9.19	9.19	9.19	9.19
	Total	76.60	103.73	130.86	157.98	185.11

Table 6–29. System Throughput Using 16 CPUs (workload = 100 + 10 scenes/day)

16-CPU Configuration (CPU Performance Degradation Factor = 14%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Time to process 16 WRS scenes Using 16 CPUs (minutes)	93.57	118.57	143.91	169.59	195.54
Maximum daily throughput (scenes/day)	184	145	120	101 **	88 **
Time to process 100 scenes + reprocess 10 scenes (hours)	10.8	13.6	16.5	19.5	22.5
** : can not support the required workload with the assumption that the system can only be 75% utilized					

6.3.6.3 Resource Utilization

6.3.6.3.1 CPU, FDDI, and Disk I/O

Table 6-30 shows the CPU, FDDI and disk I/O utilization as a function of the number of cycles for average instructions over a period of 24 hours. The worst case average scene size is used in the utilization calculation. Separate values are provided for nominal processing with and without non-nominal processing (anomaly analysis).

Figure 6-7 shows the CPU utilization over a 24-hour period for nominal processing of 100 scenes and reprocessing of ten scenes using 16 CPUs as a function of CPU cycles per average instruction and actual scene size. Figure 6-8 shows the similar CPU utilization with anomaly analysis of six scenes added. Figure 6-8 shows that the CPUs can be kept less than 75 percent utilized; even the radiometric processing software only achieves 65 MFLOPS (three cycles per instruction). For nominal processing only, the CPU utilization is higher than the CPU utilization for workload 3. However, for nominal processing and non-nominal processing, the CPU utilization is lower than the CPU utilization for workload 3 because the number of scenes that need to be analyzed for anomalies remains the same while the number of CPUs increases for this workload.

6.3.6.3.2 Disk Storage

The disk storage utilization is shown in Table 6-8.

6.3.6.3.3 Memory Requirements

The memory required to process each band of data for different scene sizes is shown in Table 6-5.

Table 6–30. Resource Utilization over a 24-Hour Period (workload = 100 + 10 scenes/day)

16-CPU Configuration (CPU Performance Degradation Factor = 14%)					
# of Cycles/Instruction	1	2	3	4	5
Equivalent MFLOP	195	97.5	65	48.75	39
Nominal processing & non-nominal processing					
CPU	35.95%	50.32%	64.68%	79.04%	93.41%
FDDI data transfer	44.79%	44.79%	44.79%	44.79%	44.79%
Disk I/O	11.83%	11.83%	11.83%	11.83%	11.83%
Nominal processing only					
CPU	32.18%	45.13%	58.08%	71.04%	83.99%
FDDI data transfer	28.80%	28.80%	28.80%	28.80%	28.80%
Disk I/O	10.36%	10.36%	10.36%	10.36%	10.36%

Figure 6–7. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Nominal Processing Only) (workload = 100 + 10 scenes per day)

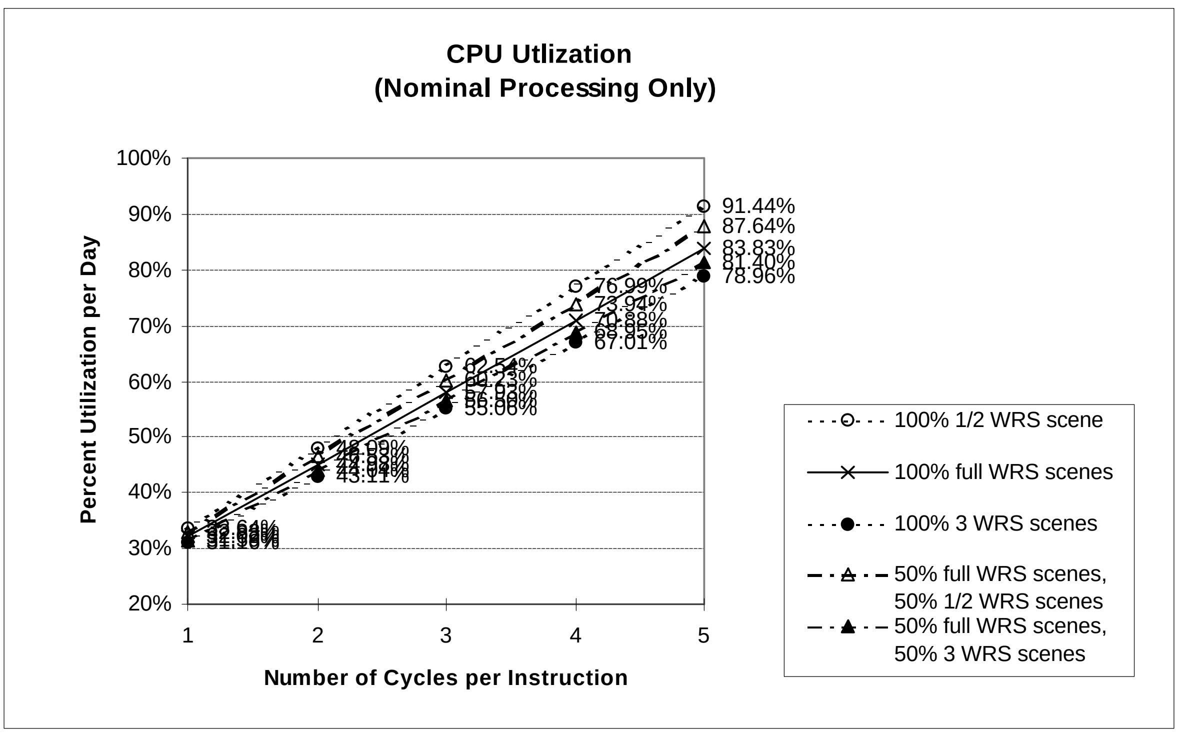
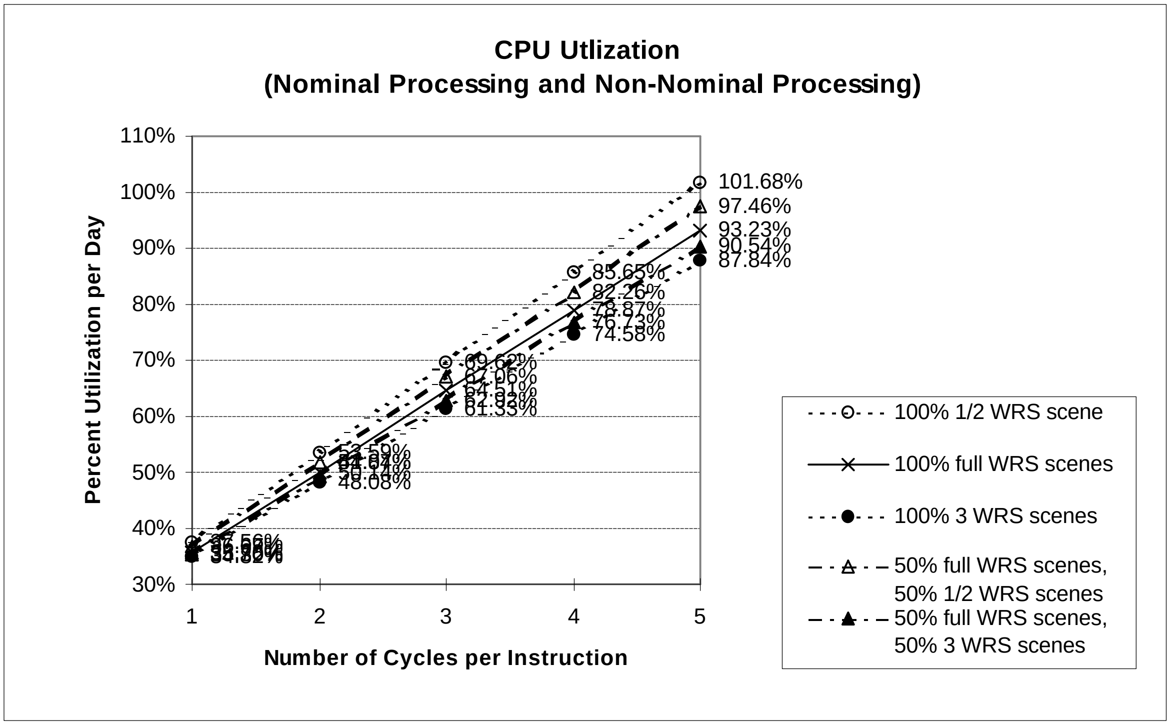


Figure 6–8. CPU Utilization per Day As a Function of Scene Size and Number of CPU Cycles per Instruction (Including Non-nominal Processing) (workload = 100 + 10 scenes per day)



6.3.6.4 Timing of Staging L0R Product for LPGS by ECS

According to modeling results from ECS, the average turnaround time for staging L0R data varies from 1/2 hour during the graveyard shift (the shift with the best turnaround time) to three hours during the second shift (the shift with the worst turnaround time). If the average turnaround time for staging a single L0R product is three hours, the turnaround time for some products could be much longer than three hours. This section is to examine the effects of the L0R turnaround time on the LPGS performance. In particular, it attempts to determine whether the LPGS can meet the workload of processing 110 scenes per day (100 required plus ten reprocessed scenes) as a function of the turnaround time.

The analysis will be done for two scenarios: the normal scenario and the worst case scenario.

6.3.6.4.1 Normal Scenario (Best Case Scenario)

In the normal scenario, it is assumed that all the L0R products to be processed are one scene in size. Based on results from section 6.3.6.2, assuming that the average radiometric processing instruction takes two cycles to execute, it takes about two hours (118.57 minutes) to process four scenes with four processors. If the total number of scenes that can be held in the input buffer is 48, with 16 processors, it takes six hours before running out of data for processing. Therefore, as long as the turnaround time for L0R products is less than six hours, none of the 16 processors needs to wait for data. This is the best case since the idle time is minimal.

The following equations show the average idle time and percent system idle time as a function of L0R turnaround time and input buffer size.

$$T_{\text{Average Idle}} = ((T_{\text{Turnaround time for L0R}}) - (T_{\text{WRS scene N}}) * (B_{\text{size}})/N) \quad \text{if } (T_{\text{Turnaround time for L0R}}) > (T_{\text{WRS scene N}}) * (B_{\text{Size}})/N$$

$$\text{or} \quad 0 \quad \text{if } (T_{\text{Turnaround time for L0R}}) <= (T_{\text{WRS scene N}}) * (B_{\text{Size}})/N$$

and

$$\%_{\text{System Idle}} = (T_{\text{Average Idle}}) / (T_{\text{Turnaround time for L0R}}) * 100\%$$

where

$T_{\text{Average Idle}}$:	Average idle time per processor
$T_{\text{Turnaround time for L0R}}$:	Turnaround time for L0R data
$T_{\text{WRS scene 1}}$:	Time to process one scene with one processor
$T_{\text{WRS scene N}}$:	Average time to process N scenes with N processors
B_{Size} :	Number of scenes that can be held in the input buffer
N:	Number of processors
$\%_{\text{System Idle}}$:	Percent of time the system is idle awaiting data to process.

Table 6-31 shows the average idle time ($T_{\text{Average Idle}}$) for a duration equal to the turnaround time as a function of the turnaround time and input buffer size. Table 6-32 shows the corresponding percent system idle time. Table 6-33 shows the number of scenes that can be processed per day assuming that processors are only 75 percent utilized. Even if the turnaround time is seven hours the LPGS can satisfy the required daily workload of retrieving, processing and transferring 100 scenes and reprocessing ten scenes in the normal situation if the input buffer can hold 48 scenes.

Table 6–31. Average Idle Time (in hours) per Processor (best case)
(for a duration equal to turnaround time)
(workload = 100 + 10 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
24	0.0	0.0	0.0	1.0	2.0	3.0	4.0	5.0	6.0
30	0.0	0.0	0.0	0.3	1.3	2.3	3.3	4.3	5.3
36	0.0	0.0	0.0	0.0	0.5	1.5	2.5	3.5	4.5
42	0.0	0.0	0.0	0.0	0.0	0.8	1.8	2.8	3.8
48	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.1	3.1
54	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.3	2.3

Table 6–32. Percent System Idle Time (best case) (workload = 100 + 10 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
24	0.0%	0.0%	0.8%	25.6%	40.5%	50.4%	57.5%	62.8%	66.9%
30	0.0%	0.0%	0.0%	7.0%	25.6%	38.0%	46.9%	53.5%	58.7%
36	0.0%	0.0%	0.0%	0.0%	10.8%	25.6%	36.3%	44.2%	50.4%
42	0.0%	0.0%	0.0%	0.0%	0.0%	13.2%	25.6%	34.9%	42.2%
48	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	15.0%	25.6%	33.9%
54	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.4%	16.3%	25.6%

Table 6–33. Number of Scenes that can be Processed per Day (assuming 75 percent utilization) (best case) (workload = 100 + 10 scenes/day)

Input Buffer Size	Turnaround Time (hours)								
(# of Scenes)	1	2	3	4	5	6	7	8	9
24	145.2	145.2	144.0	108.0	86.4	72.0	61.7	54.0	48.0
30	145.2	145.2	145.2	135.0	108.0	90.0	77.1	67.5	60.0
36	145.2	145.2	145.2	145.2	129.6	108.0	92.6	81.0	72.0
42	145.2	145.2	145.2	145.2	145.2	126.0	108.0	94.5	84.0
48	145.2	145.2	145.2	145.2	145.2	144.0	123.4	108.0	96.0
54	145.2	145.2	145.2	145.2	145.2	145.2	138.9	121.5	108.0

The above results also apply to the situation where all L0R products to be processed are of the same size.

6.3.6.4.2 Worst Case Scenario

The results for the normal scenario are also true if the size of L0R products in the input buffer is larger than the size of the incoming L0R products yet to be staged by ECS. Under these situations, initiation of processing of a L0R product will allow for transferring of at least one L0R product from ECS. The input buffer can be kept close to the maximum level.

However due to the variations in L0R product size, even with very short turnaround time, some of the processor(s) will start to become idle once it has completed processing the last work order while the new L0R product has not yet arrived.

Considering the following simplified scenario:

- single processor
- the input buffer size is three scenes

- the last L0R product ($L0R_{last}$) in the input buffer is 1/2 scene in size
- the new L0R product ($L0R_{new}$) to be staged by ECS is three scenes in size.

To avoid overflow of the input buffer, the Acquire Request for the new L0R product ($L0R_{new}$, size = three scenes) can not be sent until the last L0R product ($L0R_{last}$, size = 1/2 scene) has begun to be processed. Even if the turnaround time is two hours, by the time the new L0R product ($L0R_{new}$) is available the processor has been idle for one hour. (It takes one hour to process one 1/2 scene of data.)

The above simplified example can be generalized to derive the "very" worst case scenario. The "very" worst case scenario occurs when all the L0R products in the input buffer are 1/2 scenes in size while all the L0R products waiting to be staged are three scenes in size.

Table 6-34 shows the total idle time ($T_{Total\ Idle}$) in processor-hours for the reference duration as a function of the turnaround time and input buffer size. The "reference duration" is defined as the time interval between the start of processing of the first old L0R product and the completion of staging of the 16th new L0R product. The reference duration is used to measure the percent system idle time. Unlike the normal scenario, the reference duration varies depending on the buffer size and turnaround time.

Table 6-35 shows the corresponding percent system idle time. Table 6-36 shows the number of scenes that can be processed per day assuming that processors are only 75 percent utilized.

Under the worst case scenario, if the turnaround time is six hours the LPGS can still satisfy the required daily workload of retrieving, processing and transferring 100 scenes and reprocessing ten scenes with the input buffer size of 48 scenes.

6.3.6.4.3 Summary

Table 6-33 and Table 6-36 summarize the two extreme cases (best case and worst case) for the number of WRS scenes that can be processed per day as a function of the turnaround time and input buffer size. From these two tables, it can be concluded that if the input buffer can hold 48 scenes, the requirement of retrieving, processing and transferring 28 scenes per day (including reprocessing of three scenes) can be met with a turnaround time of 6-7+ hours. Therefore if the average turnaround time is three hours the timing issue regarding the L0R product should not be a concern. To have a true "in-time" processing, the size of the input buffer should be kept small. If the size of the input buffer is reduced to 36 scenes, the requirement can still be met with a turnaround time of 4-5+ hours.

Table 6–34. Average Idle Time (in hours) per Processor (worst case)
(for a duration equal to reference duration)
(workload = 100 + 10 scenes/day)

Input Buffer Size (# of Scenes)	Turnaround Time (hours) 1	2	3	4	5	6	7	8
	Total Idle Time (processor-hours)							
24	6.0	22.0	44.0	68.0	92.0	116.0	140.0	164.0
30	3.0	12.5	28.5	49.5	71.5	93.5	115.5	137.5
36	1.5	8.5	19.0	34.0	54.0	74.0	94.0	114.0
42	0.5	5.5	13.5	24.5	39.5	57.5	75.5	93.5
48	0.0	2.5	8.0	17.0	29.5	44.0	60.0	76.0
54	0.0	0.5	3.5	10.0	19.5	32.5	48.0	64.0
	Reference Duration (hours)							
24	4.8	6.8	8.8	10.8	12.8	14.8	16.8	18.8
30	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0
36	5.5	6.5	7.5	9.3	11.3	13.3	15.3	17.3
42	6.3	7.3	8.3	9.3	10.5	12.5	14.5	16.5
48	6.8	7.8	8.8	9.8	10.8	11.8	12.8	13.8
54	7.5	7.8	8.8	9.8	10.8	11.8	12.8	13.8

Table 6–35. Percent System Idle Time (worst case)
(workload = 100 + 10 scenes/day)

Input Buffer Size (# of Scenes)	Turnaround Time (hours) 1	2	3	4	5	6	7	8
24	7.9%	20.4%	31.4%	39.5%	45.1%	49.2%	52.2%	54.7%
30	3.8%	13.0%	22.3%	30.9%	37.2%	41.7%	45.1%	47.7%
36	1.7%	8.2%	15.8%	23.0%	30.0%	34.9%	38.5%	41.3%
42	0.5%	4.7%	10.2%	16.6%	23.5%	28.8%	32.5%	35.4%
48	0.0%	2.0%	5.7%	10.9%	17.2%	23.4%	29.4%	34.5%
54	0.0%	0.4%	2.5%	6.4%	11.3%	17.3%	23.5%	29.1%

Table 6–36. Number of WRS Scenes that can be Processed per Day (worst case) (assuming 75 percent utilization) (workload = 100 + 10 scenes/day)

Input Buffer Size	Turnaround Time (hours)							
(# of Scenes)	1	2	3	4	5	6	7	8
24	133.7	115.6	99.6	87.8	79.7	73.8	69.4	65.8
30	139.8	126.3	112.9	100.3	91.1	84.6	79.7	75.9
36	142.7	133.3	122.2	111.9	101.6	94.5	89.3	85.2
42	144.5	138.3	130.4	121.2	111.1	103.5	98.0	93.8
48	145.2	142.3	136.9	129.4	120.3	111.2	102.5	95.0
54	145.2	144.6	141.6	135.9	128.7	120.1	111.0	103.0